EFT
Ecological Flows Tool

The Ecological Flows Tool (EFT) is a decision support system that demonstrates how changes in flow management (and other actions) result in changes to the physical habitats for multiple species within the Sacramento River and the Delta. EFT works by integrating a range of representative functional ecological response indicators with key physical variables obtained from widely used hydrologic models. EFT transparently relates multiple attributes of the flow regime to multiple species' life-history needs, contributing to an effective understanding of flow and non-flow restoration actions on focal species and their habitats. The hallmark of the EFT approach is integration and clear communication of multiple ecological tradeoffs associated with different water operation alternatives.

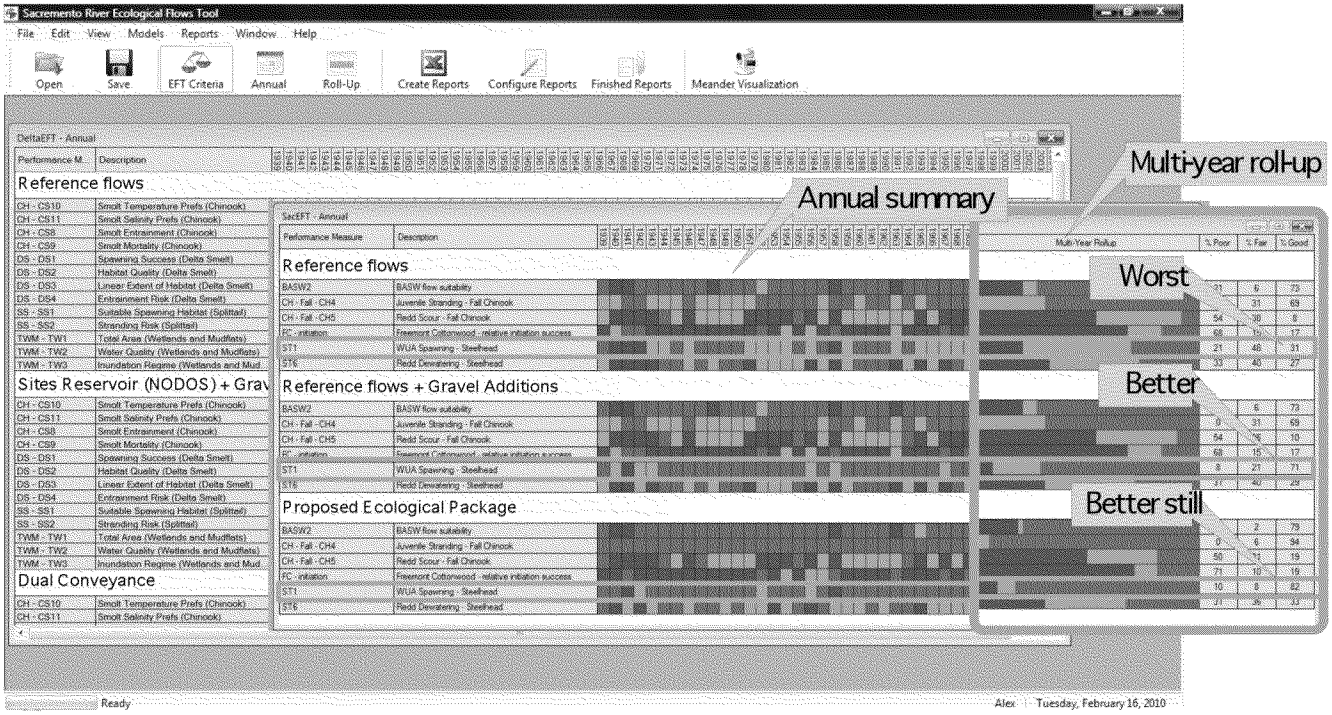

Figure 1 » Example of annual and multi-year roll-up traffic light indicator ratings

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multiple focal Species & Indicators

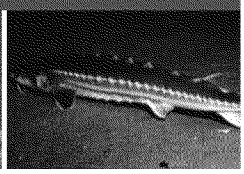
In all, EFT includes conceptual models for eleven (11) species and twenty four (24) causally reasoned performance indicators (Figure 2). EFT performance indicators are based on a mixture of process-based ecological functions and empirical relationships between flow, habitats, and focal species response. EFT's representative ecological indicators capture the essence of existing conceptual models and are driven by widely used physical models for flow, stage, salinity, and water temperature. Intuitive output interfaces allow cross-walking of ecological consequences over policy alternatives.

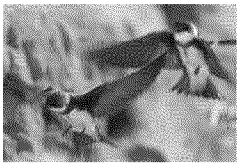
Focal SpecieS & HabitatS

Sacramento River

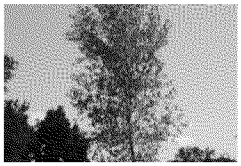

Steelhead trout


Chinook salmon


Green sturgeon

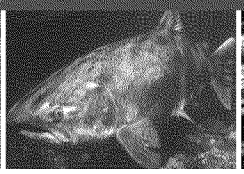

Bank swallow


Western pond turtle

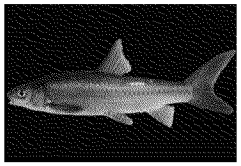

Fremont cottonwood

Delta Ecoregion


Steelhead trout


Chinook salmon


Delta smelt


Splittail


Tidal wetlands


Invasive species deterrence

Sacramento River

focal Species & Habitats	Performance measures	
Fremont cottonwood	FC1	Successful cottonwood initiation
	FC2	Cottonwood seedling scour
Bank swallow (BASW)	BASW1	Habitat potential/suitability
	BASW2	Risk of nest inundation and bank sloughing during nesting
Western pond turtle	LWD1	Index of old vegetation recruited to the Sacramento River mainstem
Green sturgeon (GS)	GS1	Egg-to-larvae survival
Chinook salmon, Steelhead trout (CS)	CS1	Area of suitable spawning habitat (ft^2)
	CS3	Egg-to-fry survival (proportion)
	CS5	Redd scour (hazard zones)
	CS6	Redd dewatering (proportion)
	CS2	Area of suitable rearing habitat (ft^2)
	CS4	Juvenile stranding (index)

Delta Ecoregion

focal Species & Habitats	Performance measures	
Chinook & Steelhead (CS)	CS7	Smolt weight gain in alt. migration corridors
	CS9	Smolt mortality index as a funtion of passage time (negatively correlated with CS7)
	CS10	Smolt temperature preference index (departures from optimum v. weight gain)
Delta smelt (DS)	DS1	Spawning success index
	DS2	Index of habitat suitability
	DS4	Entrainment risk (index)
Splittail (SS)	SS1	Proportion of maximum potential spawning habitat (index)
Fresh/brackish tidal wetlands (TW)	TW1	Brackish wetland area
	TW2	Freshwater wetland area
Invasive species deterrence (ID)	ID1	Brazilian waterweed suppression
	ID2	*(Corbula)* Invasive clam larvae and recruit suppression
	ID3	*(Corbicula)* Invasive clam larvae and recruit suppression

Figure 2 » Species and their performance measures in EFT.

EFT is structured as an "ecological plug-in" to existing models that are commonly used for water planning in the Central Valley (Figure 3). Rather than reinventing models, EFT utilizes output data sets from daily disaggregations of CALSIM, DSM2, and other models that are used to investigate water delivery and other standards set for the CVP and SWP water system. EFT utilizes these data and adds ecological calculations to evaluate effects on multiple ecosystem targets.

Extensive scientific understanding of the Sacramento River and Delta ecosystem's likely response to changes in flow management has been developed over the past twenty years. Prior to EFT, much of this important information existed in a multitude of separate reports, independent conceptual models, and unconnected modeling tools. EFT has synthesized much of this disparate information, linking ecological submodels to existing physical planning models, providing a major advance in the region's capabilities for assessing ecological tradeoffs. The EFT framework also makes it easy to "swap in" (or remove) indicators as the state of scientific knowledge evolves.

The functional relationships and indicators that are encapsulated into the decision support tool represent the collective thoughts of more than seventy scientists from state and federal agencies, consulting firms, and research institutions who have participated in our workshops or who wrote primary papers on which the relationships are based.

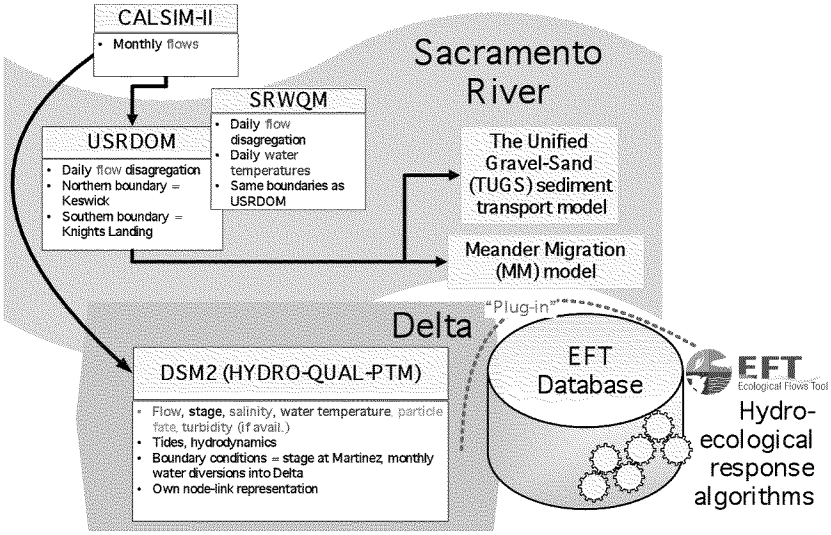


Figure 3» EFT hydrologic foundation. Note: Physical models used in DeltaEFT are not necessarily limited to those shown here. Where it is feasible and practical to obtain outputs at a daily resolution for multi-decadal simulations, other models can be "swapped in" if they are deemed a better representation of the physical variables of interest.

In addition to integrating disparate sources of information, a challenge overcome by EFT's design is translating information into easily understandable results for managers. Practical synthesis and integration is challenging when considering multiple ecological targets, complex physical models, and multiple audiences (e.g., high-level managers as well as technical-level staff). EFT creates output that can span the range from high overview to daily and location-specific detail. The output interface makes extensive use of a "traffic light" paradigm that juxtaposes performance measure results and scenarios to provide an intuitive overview of whether a given year's performance measure are healthy (green), of some concern (yellow), or of serious concern/poor (red).

EFT's output interface and reports for trade-off analyses make it clear how actions

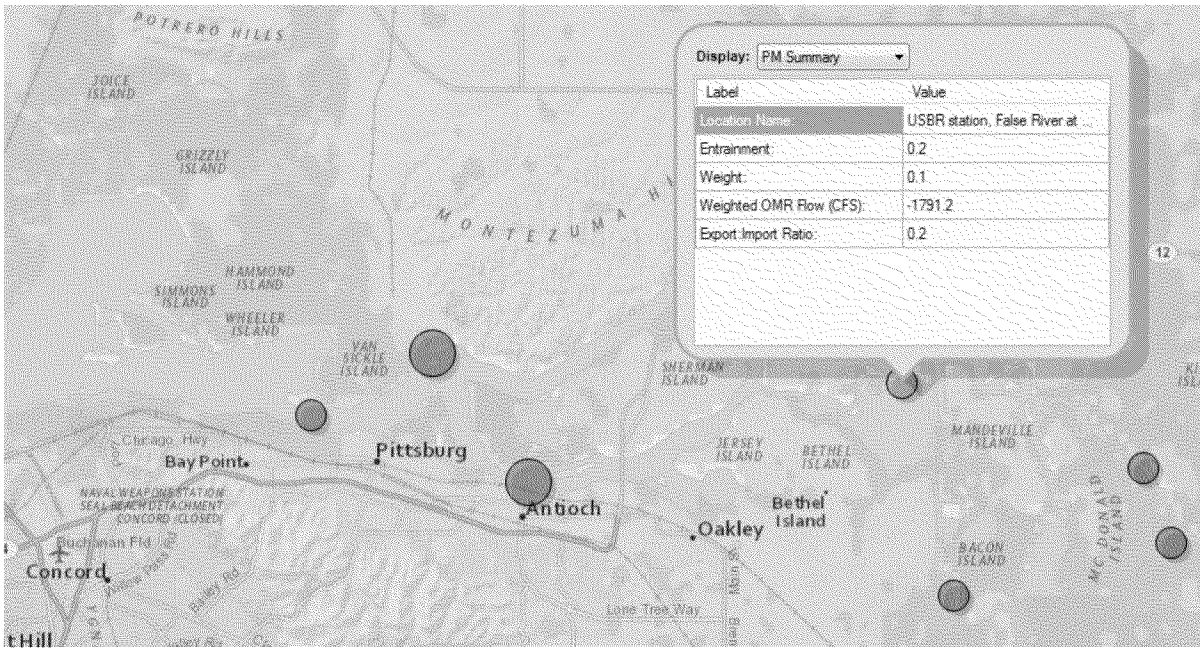


Figure 4» Example of map-based output information for DS4: Index of risk of entrainment.

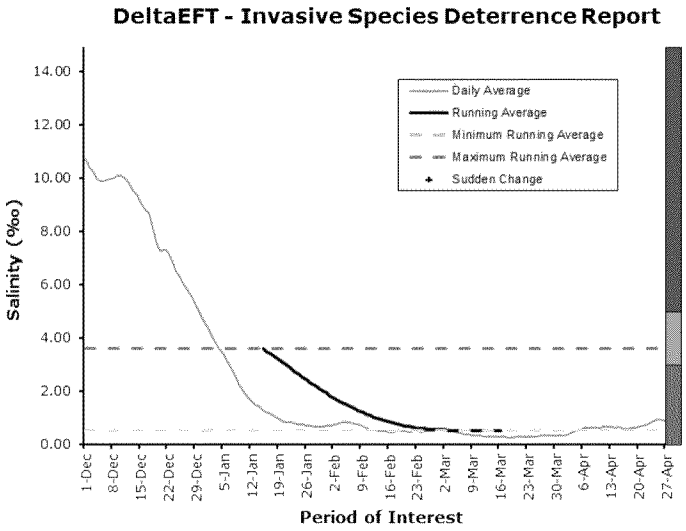


Figure 5 » Example of Excel output graph information for ID2: Brackish water invasive overbite clam suppression.

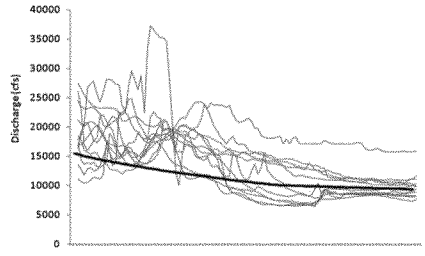
ecoregion												
Species												
Indicator	FC1	Cottonwood relative initiation success										
Objective	Periodically provide recession flows that support areas for riparian initiation											
Timing	O	N	D	J	F	M	A	M	J	J	A	S
Location	Hamilton City (RM199)											
Variable & Condition												
Recurrence	At least once every 8 years											

Figure 6 » Example of functional flow recommendation for one EFT indicator.

implemented for the benefitof one area or focal species may affect (both positively and negatively) another area or focal species. Forexample, we can show how altering Sacramento River flows to meet export pumping schedules in the Delta affects focal species' performance measures both in the Sacramento River and the Delta.

One of the biggest challenges in the practical development of ecological flowregime guidelines is the wide range of objectives, focal species, and habitat types that need to be considered. EFT has brought into focus how these various objectives cannot all be simultaneously met. In nature, conditions often benefitone target or species to the potential detriment of another in any given year. Fortunately, flowcharacteristics that benefitthe various ecological targets investigated are usually required on a periodic basis and not every single year. EFT studies simplify communication of these trade-offs and catalyze definitionof state-dependent management practices that promote the development of needed flexibility in the water management system.

EFT focal species submodels are integrated and centered on a single SQL server relational database. The software's graphical user interface, model controller & analysis engine, and Excel & map visualization output reporting connect to and interact with this central database over the web. Users may perform Sacramento River (SacEFT) or Delta (DeltaEFT) effects analyses separately or in conjunction with one another. Users can choose which management scenarios to evaluate, what range of years to display, and which ecological indicators they wish to evaluate.

What Doeseft Contribute to Water esource anagement?

EFT contributes to a more comprehensive understanding of how proposed changes to water operations infrastructure and management (and future climate conditions) affect target species and habitats. EFT does not solve social value decisions about whether a particular action or alternative is "good" or "bad." Rather EFT is designed to provide information about the positive, neutral, and/or negative effects of a particular alternative, across asuite of representative focal species and their habitats. As noted above, EFT's intuitive outputs make it clear how actions implemented for the benefitof one area or focal species may influence (both positively negatively) another area or focal species.

EFT is also useful for developing functional flowguidelines. Because of the multi-species approach, EFT helps communicate how to prioritize and trade off amongst ecological objectives and adjust these priorities based on emerging conditions (e.g., water year types) and the ability to realize different objectives over time.

Software

EFT Reader software is publicly available and free to download at http://essa.com/tools/eft/download. The EFT Reader links with a centralized copy of the EFT database located on a remote server. The public EFT Reader database currently contains a suite of fully configuredscenarios, derived from the Sacramento River Ecological Flows Study and from test scenarios supplied by DWR and project partners. Future versions of the EFT Reader database will include results for simulations based on other effects analysis investigations, as they move into the public domain.

EFT was developed between 2004 and 2012 with funding from the Department of Fish and Wildlife's Ecosystem Restoration Program, The David and Lucile Packard Foundation, The Nature Conservancy, and ESSA Technologies.

additional information

- http://essa.com/tools/eft
- http://www.dfg.ca.gov/ERP/signature_sacriverecoflows.asp